

Annual Report to
NOAA's CPPA Program

SHIPBOARD MONITORING OF AIR-SEA FLUX AND CLOUD PROCESSES IN THE
SOUTHEAST PACIFIC STRATOCUMULUS REGION
GC06-087

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Period covered by this report: Oct 1, 2006 - Sept 30, 2007

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PROJECT SUMMARY

As part of the EPIC monitoring and the Ocean Observations programs, ESRL has conducted a series of cruises each year in the East Pacific to make comprehensive flux and MBL/cloud observations to supplement NOAA buoy operations and to obtain baseline observations in the SE Pacific stratocumulus region. Beginning in 1999, the cruises were done in the spring and fall along 95 and 110 W. In 2003, the spring cruise was supplanted by a fall cruise to the Woods Hole Ocean Reference Station (ORS) buoy at 20 S 85 W. The cruises are done in *piggyback* mode; ESRL sensors are installed on the ships servicing the buoys. This work is done in collaboration with Meghan Cronin (PMEL) on TAO buoys and Bob Weller (WHOI) on the ORS buoy at 20 S 85 W. The University of Miami (cloud radars) and the Texas A&M University (aerosols) have also collaborated by deploying measurement systems. CPPA now supports the complete effort for one cruise to the stratocumulus region (air-sea fluxes, PBL properties, and clouds) plus analysis per year. Cloud microphysics observations will be significantly improved by deploying a new motion-stabilized 94-GHz radar by 2008.

In this project we plan a ship-based measurement program to obtain statistics on key surface, MBL, low-cloud macrophysical and microphysical, and radiative properties relevant to NOAA's CPPA VOCALS Program. We place a suite of instruments on NOAA (or UNOLS) ships servicing the WHOI ORS buoy at 20 S 85 W each fall. The basic objectives of these measurements are to:

- *Increase the utility of long time series buoy observations of air-sea fluxes through intercalibration, atmospheric profiles, cloud properties, and spatial context.
- *Provide comprehensive information for operational weather forecast model evaluation/development and satellite calibration/validation and algorithm development
- *Advance development of bulk turbulent and radiative flux parameterizations either directly or

by linking with LES and CRM research efforts.

*Advance understanding of the role of MBL clouds, aerosols, and drizzle in cloud radiative forcing

*Providing seasonal and interannual context for the VOCALS program.

FY2007 Results and Accomplishments

The priorities for work in FY07 were execution of a cruise in fall 2006, completion of remaining data processing tasks, analysis of data, some synthesis activities for data obtained in the previous years (2001, 2003, 2004, 2005, 2006), examination of new technology in cloud liquid water path measurement, and preparations for the upcoming VOCALS field program. We have been working with the University of Miami group (Bruce Albrecht and Paquita Zuidema), Chris Bretherton (University of Washington), Meghan Cronin (PMEL) and Bob Weller (WHOI) on synthesis of the results. This involves combining data from multiple cruises to improve the statistics or obtain information on interannual variability. A major effort was devoted to consolidating all of the data streams from the previous stratus cruises and writing all the data in one consistent format. A paper was submitted in 2006 and was accepted after revisions in 2007 (Fairall et al., 2006) summarizing the results of four years of cruises in the equatorial E. Pacific. A second paper was submitted based on analysis of all WHOI buoy observations (2000-2006) to produce annual cycle of cloud fraction and cloud radiative forcing in the stratocumulus region (Viendra Ghate, U. Miami).

Annual Cycle of Stratocumulus Properties from Buoy Observations

Although marine stratocumulus cloud coverage is regarded as one of the most significant regulators of the radiation budget over the eastern subtropical oceans, it is poorly represented in global climate models. The Woods Hole Oceanographic Institute (WHOI)'s Ocean Reference Station (WORS) located at 20° S 85° W has collected observations of surface thermodynamic variables and broadband radiative fluxes continuously since October 2000. A technique to derive stratocumulus cloud fraction using the WORS observations is presented and applied to the buoy observations to give a five-year climatology (for 2001-2006). The technique uses the surface downward longwave (LW) fluxes along with the clear sky LW flux estimated from a model calibrated during five WORS maintenance cruises conducted in the region. The results are compared with the satellite derived monthly cloud fraction and the ceilometer derived zenith cloud fraction (available during the maintenance cruises). The initial results and analysis show that the technique can be effectively applied to the longer datasets and the continuous observation from the WORS. Seasonal, inter-seasonal and average diurnal variations in cloud cover are obtained for five years of observations. Figure 1 shows a sample result from this study. Here we plot monthly averaged cloud fraction beginning in 2001 and running until fall of 2006. The buoy-derived cloud fractions are compared with ISSCP satellite-derived low-cloud and total cloud fractions. Note that the satellite gets total cloud well, but is completely wrong on the partitioning between cloud heights. We are conversing with NASA on the solution to this problem.

Aerosol Depletion Processes in POCs

For the Stratus07 cruise the ship departed Panama as planned the morning of October 16. Observations were officially begun on October 18. The ship reached 20 S 75 W by the end of October 22 and spent almost two days at that location before departing to the west on October 24 and arriving at the WHOI buoy at 20 S 85 W on about 1200 GMT October 26 (Fig. 1), then departed this location 1200 GMT October 31. The ESRL observations include air-sea fluxes/near-surface bulk meteorology, cloud ceilometers, radar wind profiler, scanning Doppler C-band precipitation radar, a microwave radiometer for column water vapor/liquid, and aerosols in the 0.1 to 6 micrometer range. Rawinsonde launches are being made every 4 hours (at the WHOI buoy). Pockets of Open-cell Convection (POC) were encountered on Days 301 and 302. Fig. 2 shows the time series of aerosol observations for the region near the WHOI buoy. The passage of the POCs is apparent in the decrease in aerosol concentrations (particularly at small sizes). Note that on Day 301 The passage of a small POC is apparent as the W-shaped feature in the aerosol concentration early on JD 301 and another late on JD302. In both cases it looks like the depletion of aerosols was a maximum at the leading and following edge of the POC. The clear period on October 30 does not appear to be associated with a POC. This is consistent with radar observations from the EPIC2001 field program (Comstock, K.K., S. E. Yuter, R. Wood, and C. S. Bretherton, 2007: The three-dimensional structure and kinematics of drizzling stratocumulus. *Mon. Wea. Rev.*, in press; Comstock, K. K., C. S. Bretherton, and S. E. Yuter, 2005: Mesoscale variability and drizzle in southeast Pacific stratocumulus. *J. Atmos. Sci.*, **62**, 3792-3807.)

Highlights

- *Completed cruise to WHOI buoy site (20 S 85 W) in Oct. 2006.
- *Reprocessed direct flux time series for 2006.
- *Submitted two synthesis papers on previous years work.
- *Completed organization of stratus cruise data base and performed preliminary synthesis calculations.
- *Constructed and tested pitch/roll stabilization system.
- *Found evidence for aerosol precipitation processing maxima at the edges of POCs.
- *Presented invited paper at IUGG Perugia, Italy, July 2 2007. *Shipboard Investigation of Air-sea Interaction and Cloud Processes in the VOCALS Stratocumulus Region*. **C. W. Fairall**, D. Wolfe, S. Pezoa, Simon DeSoeke, L. Bariteau, Bruce Albrecht, Efthymios Serpetzoglou, Virendra Ghate, and Paquita Zuidema.

FY2008 PLANS

The priority for work in FY08 will be completion of remaining synthesis analysis of the stratus region data and the submission of publications on that analysis. The primary tasks remaining are 1) write a paper on bulk flux relationships in the East Pacific stratocumulus region, 2) perform retrievals of cloud microphysics from the cloud radar data and write a paper on microphysics – cloud radiative relationships (a followup to the Zhou et al. 2006 study), and 3) generate a 5-year climatology of surface and PBL properties from the status cruises and match

that up with the annual cycle from the WHOI buoy observations. The latter task is intended to lead to a synthesis paper on the atmospheric and oceanic properties at the stratus buoy location.

Secondary tasks will include participation in the fall 2007 stratus cruise and preparations/planning for the VOCALS field program. In fall 2006 performed direct flux measurements of ozone (with D. Helmig, University of Colorado) and DMS (with B. Huebert, University of Hawaii), which will be analyzed in FY08. These gas transfer observations will provide new perspectives on ocean biology coupling to marine aerosols in the region. This will be important preliminary groundwork for VOCALS.

PUBLICATIONS

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Cronin, M. F., N. Bond, C. W. Fairall, and R. A. Weller, 2006a: Surface cloud forcing in the Eastern Tropical Pacific. *J. Clim.*, **19**, 392-409.

Cronin, M., C. W. Fairall, and M. J. McPhaden, 2006b: An assessment of buoy-derived and numerical weather prediction surface heat fluxes in the tropical Pacific. *J. Geophys. Res.*, **111**, C06038, doi:10.1029/2005JC003324.

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Ghate, Virendra P., Bruce A. Albrecht, Christopher W. Fairall and Robert A. Weller, 2007: Climatology of Marine Stratocumulus Cloud Fraction in the South-East Pacific Using Surface Longwave Radiative Flux Observations. *J. Climate*, Submitted.

R. Wood, K. K. Comstock, C. S. Bretherton, C. Cornish, J. Tomlinson, D. R. Collins, and C. W. Fairall, 2007: Open cellular structure in marine stratocumulus sheets. *Q. J. Roy. Met. Soc.*, submitted.

Figure Captions

Figure 1. Monthly averaged buoy cloudiness compared with ISCCP monthly averaged low and total cloudiness at buoy location.

Figure 2. Time series of aerosol concentrations from October 26 through October 30, 2007 on the Stratus07 cruise at 20 S 85 W. Upper panel: Total concentration for sizes from 0.1 to 5 micrometer. Lower panel: size resolved concentrations.

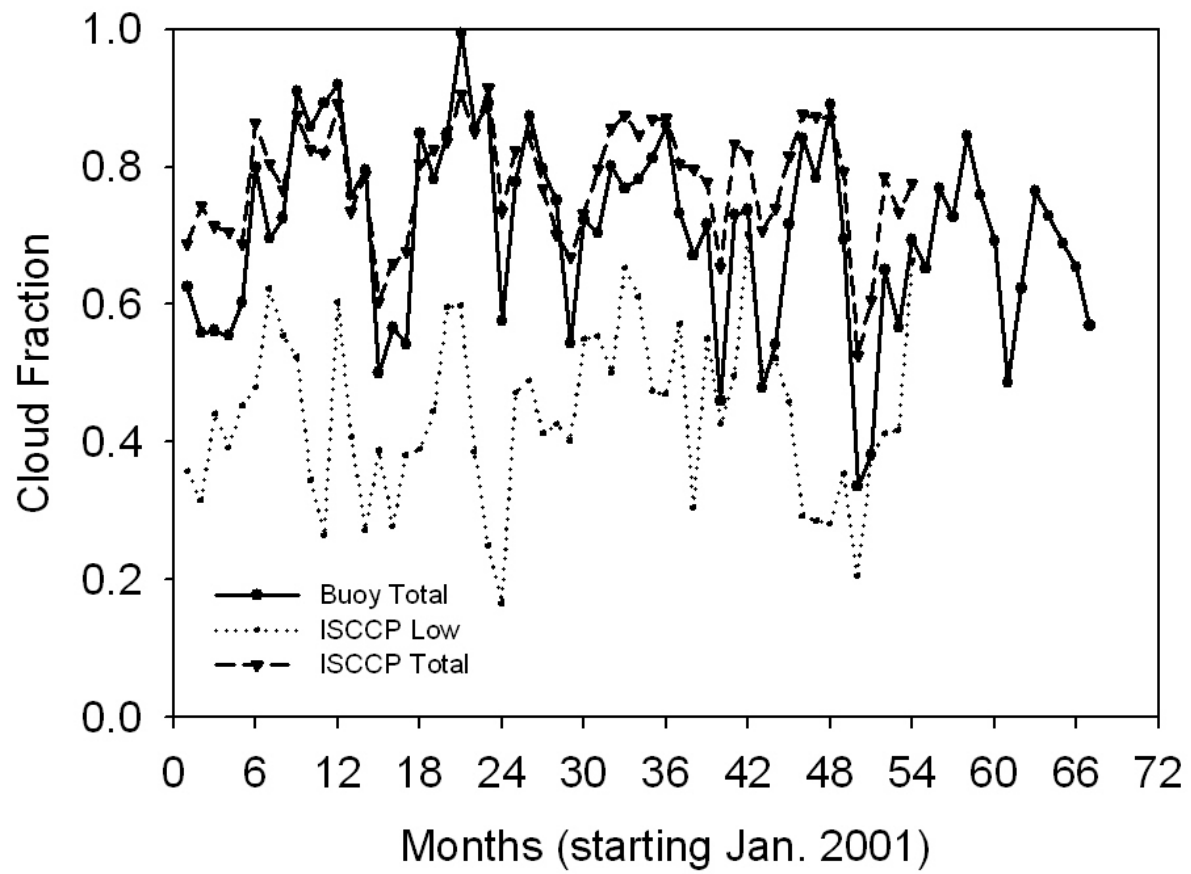


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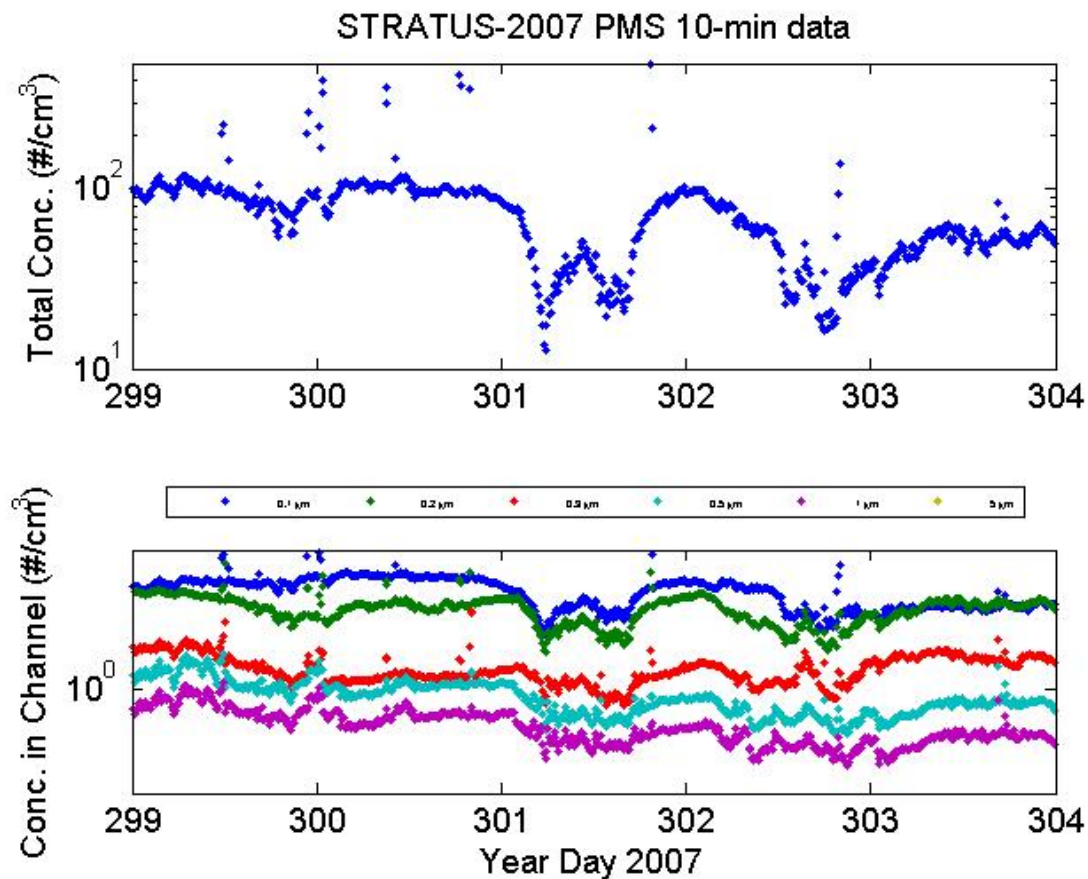


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